Title: PROCESS FOR MEASURING PHASE CURRENTS OF A DEVICE FOR CONTROLLING ELECTRIC MOTORS MADE WITH IMS TECHNOLOGY OR THE LIKE EMBEDDING, FOR SUCH MEASURE, RESISTANCE AND TEMPERATURE CONTROL DEVICE FOR POWER TRANSISTORS.

DESCRIPTION

The present invention deals with a process for measuring phase currents in an inverter or a DC controller for supplying electric motors and an inverter or DC controlled in IMS technology or the like embedding resistances for this measure.

The term inverter or DC controller means any control device for electric motors including Permanent Magnet Motors, Serial Motors, Separate Energisation Motors, Split Motors, Stepped Motor, DC Brushless Motors, AC Brushless Motors, Synchronous Motors, Asynchronous (Induction) Motors, Reluctance Motors and others.

The term IMS technology or the like refers to any arrangement realising a power stage for controlling motors characterised in having:

- copper connection paths between elementary power devices and access terminals towards the outside (typically, but not exclusively, made with the photo-etching method used in printed circuits): such paths are electrically insulated from the substrate below (typically metallic

and herein below called Base) by a layer of insulating material;

- a high thermal capacity so that the temperature of all Base points can be deemed homogeneous, with a limited error;
- a low thermal resistance between the above copper paths and the die (body) of elementary power devices so that temperature of power devices (on die) and temperature of copper paths on which they are applied, can be equalised, with a limited error;
- a low thermal resistance between the above copper paths and the metal Base below so that temperature of copper paths and temperature of metal Base below can be equalised, with a limited error.

In the electric motors supplying systems, through inverter or DC controller, it is necessary to monitor in real time two major parameters to avoid system damages, namely:

- power devices (power transistors) temperature through a thermal sensor;
- current absorbed by the electric motor, in particular.

When supplying two-phase and three-phase motors, applications are known where currents of at least two phases are measured.

For checking motors in cc applications are know where armature current is measured.

As an alternative, whatever the motor type is, applications are known in which current is measure on the power line or in series with power devices.

For monitoring currents, a known technique provides for inserting precision shunt resistances, without thermal drift, namely without resistance variation when the temperature changes.

This allows measuring inverter or DC controller currents with extreme accuracy.

This known arrangement, though being technically valid, has the inconvenience of being costly and cumbersome due to the insertion of these shunts.

The thermal sensors are applied, according to the known art, next to power transistors to detect their temperature.

Object of the present invention is thereby reducing manufacturing costs and times, reducing encumbrance of an inverter or DC controller of the type with IMS (Insulated Metal Substrate) technology or the like, increasing assembly reliability and solving the problem of thermally exhausting the dissipated power from precision resistances, all this without impairing measure efficiency and accuracy.

Arrangements in IMS technology and the like are dealt with having to include arrangements, typically called

differently from IMS, but substantially characterised in the same way as regards the present invention.

An abbreviation for everything that falls within the above scope is DBC (Direct Bonded Copper), and is the realisation technique for integrated power modules (Power Semiconductor Modules) that are composed of a copper substrate, of an insulating layer (typically ceramics) and of the overlying copper plates on which power chips terminals are welded.

This object is fully reached in the present process for measuring phase currents of a control devices for electric motors, that is characterised in the below-listed claims and particularly in that in an embodiment of the IMS type (or the like) for controlling motors, copper connection paths are provided towards power devices and external connections (motor and supply line), a thermal sensor for checking power transistor temperature being preferably (but not necessarily) placed next to (or above) the path whose current has to be measured.

The current measuring process provides for the measure, through said sensor, of the temperature of a pre-existing copper adduction path, possibly elongated for such purpose, inserted in IMS technology in series with a connection terminal to the outside or with power devices, and for

compensating, through software, the path drop to have an accurate measure of current in the copper path itself.

The temperature measured on the current adduction path will be assigned, with a limited error, also to power transistor cases.

These and other features will be better pointed out by the following description of a preferred, but not exclusive embodiment, shown merely as a non-limiting example, of the enclosed table of drawing, in which:

- figure 1 shows a card portion for an inverter;
- figure 2 shows an application diagram of the current transducer position depending on control device application.

With reference to the figures, 1 shows a card made with IMS technology and namely of the type comprising an aluminium support plate for an insulating layer on which a copper circuit is included.

Reference 2 shows a copper path inserted between connection point 3 of a motor phase and power transistors 4.

On the copper path 2 a thermal sensor 5 is inserted for measuring the path temperature.

Since in the IMS system a low thermal resistance aluminium support is provided, it can be deemed that the temperature measured on the copper path is substantially

equal to the temperature existing on the power transistor base inserted in the inverter.

The process advantageously provides for compensating, through the temperature measure and through an already present software for managing the inverter, the voltage drop due to thermal drift of copper path resistivity.

Moreover, if, as in case of an inverter, the currents to be measured are more than one, it is allowed to use a single sensor on only one of the two adduction paths, provided that they have similar sizes.

This because inverter currents are balanced (the two paths are subjected to the same current state) and, as specified, it is assumed that the IMS substrate (or the like) has a sufficiently high thermal capacity to homogeneously distribute the temperature on the whole metal Base area.

The copper path can be also realised with another metal.

The thermal drift of copper resistivity is expressed by the following formula:

$\rho_T=\rho_{To}*(1+0.0039*(T-To))$

with:

ρ_T = Resistivity at Temperature T

ρ_{To} = Resistivity at Temperature To

The voltage drop on the copper path section (used for measuring) will be amplified and therefore, through an analogue-digital conversion, supplied to the processing unit. Let us call such value Vi.

The software performs a thermal compensation that is divided into the following operations:

1) the software recognises the Resistance (Ro) that the measuring path has at a certain Temperature (To)
2) the software will have a cyclic structure and, upon every iteration, will detect the actual temperature (T) by reading the thermal sensor
3) by knowing the previous temperature (T), it will compute the actual value (R_T) of the measuring path resistance according to the formula:

$$R_T = Ro\ (1+0.0039(T-To))$$

4) concluding, the software will determine the current value in the path through the relationship:

$$I = Vi/R_T$$

It has been stated that the copper path temperature (T) will be used also as approximate measure of the power transistor temperature, This is true when providing low thermal resistance hypotheses between overlapped layers.

This hypothesis can be verified on line, through software, in the following way. By knowing the copper path dissipation ($Pd=R_T I^2$) and the Thermal Resistance (Rth_{PB})

between copper Path and Base, the metal Base Temperature T_B) can be computed:

$$T_B = T - Rth_{PB} * Pd$$

Knowing T_B and the thermal resistance of power transistors, together with the thermal power they dissipate, their temperature can be computed.

With reference to figure 2, when supplying two-phase or three-phase motors, applications are known where currents are measured of at least two phases (position 11 in fig. 2), while for checking direct current motors, applications are known where the armature current is measured (position 11 in fig. 2).

Alternatively, whichever the type of motor, applications are known in which the power supply current (positions 7 and 8 in fig. 2) is measured or the current in series with power devices (positions 9 and 10 in fig. 2) is measured.